

Field Experiments in Malaria Control

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FIELD EXPERIMENTS IN MALARIA CONTROL *

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Malaria is recognized as one of the most serious of the disabling diseases of man. It is estimated that in India alone it causes on the average each year about 1,130,000 deaths and more than 100,000,000 cases of illness. The economic losses resulting from it are incalculable. The failure of the early Panama Canal project and the difficulties encountered in building the Madeira Railroad are only spectacular examples of what it is doing continuously and on an enormous scale to hinder industrial enterprise. On farming populations its burden falls with peculiar emphasis. Many of the richest agricultural lands in warm climates cannot be developed until the infection in these regions has been brought under control. The direct annual cost of the sickness and death that it produces in India alone is estimated at about \$284,000,000; and this does not take into consideration the vastly greater losses due to the impaired productive power of labor.

More serious still are its effects in retarding the development of individuals and communities. Like hookworm, the malaria plasmodium is an anemia-producing parasite. It saps the life of its victims by destroying their blood. The disease is most prevalent

* The field tests here reported under the head of malaria control by antimosquito measures, by screening, and by immunizing quinin were carried out in cooperation with the U. S. Public Health Service and the Arkansas Department of Health, Dr. H. A. Taylor having immediate charge of the antimosquito work and Dr. T. D. Haas of the screening and immunizing quinin tests. The experiment in malaria control by sterilizing the human carriers was conducted under the general supervision of the Mississippi Department of Health and under the scientific direction of Dr. C. C. Bass of Tulane Medical School. In the preparation of this paper, earlier reports, particularly the Fourth Annual Report of the International Health Board and Bulletin No. 88 of the U. S. Public Health Service, have been drawn on freely.

among children under 15 years of age, and therefore preys on the vitality of the race during the important period of physical and mental growth. Its effects, moreover, are cumulative. They are handed on from one generation to the next, and become to the community an increasing handicap in all things that make for social development. And these results are widespread. Malaria in mild form is almost world-wide in distribution, and in its malignant form belts the globe in a broad zone including tropical and semitropical regions. Of the 1,600,000,000 inhabitants of the earth, more than half live in countries in which the infection is prevalent and constitutes a serious menace to life and health and working efficiency.

And these conditions prevail in spite of the fact that malaria is a controllable disease. It is twenty years since the discovery by Ross, confirmed and extended by the Italian scientists and others, definitely established the life cycle of the malaria parasite and thus gave us the facts on which to base an intelligent program of control. It is well understood, not only by scientists but also by intelligent laymen, that the spread of the infection may be prevented by mosquito control, by protecting people from being bitten by mosquitoes, or by destroying the parasite in the blood of the human carrier. It has been shown, moreover, by repeated demonstrations that by application of any one of these measures or of any combination of them the amount of malaria in a community may be reduced indefinitely. There are few diseases that present so many vulnerable points of attack and none perhaps the control of which may be made more definite or certain. Still the infection persists. And still we refer to it as the chief obstacle to the development of civilization in the tropics. Comparatively little has been done during these twenty years to bring into general operation the practical measures for which the scientific basis has been so well laid.

THE ITEM OF COST AS A DISCOURAGING FACTOR

Nothing has done more to discourage the general application of antimalaria measures than the item of cost. Many of the early demonstrations that attracted wide attention were relatively expensive. Watson's brilliant results in the Federated Malay States, 1901

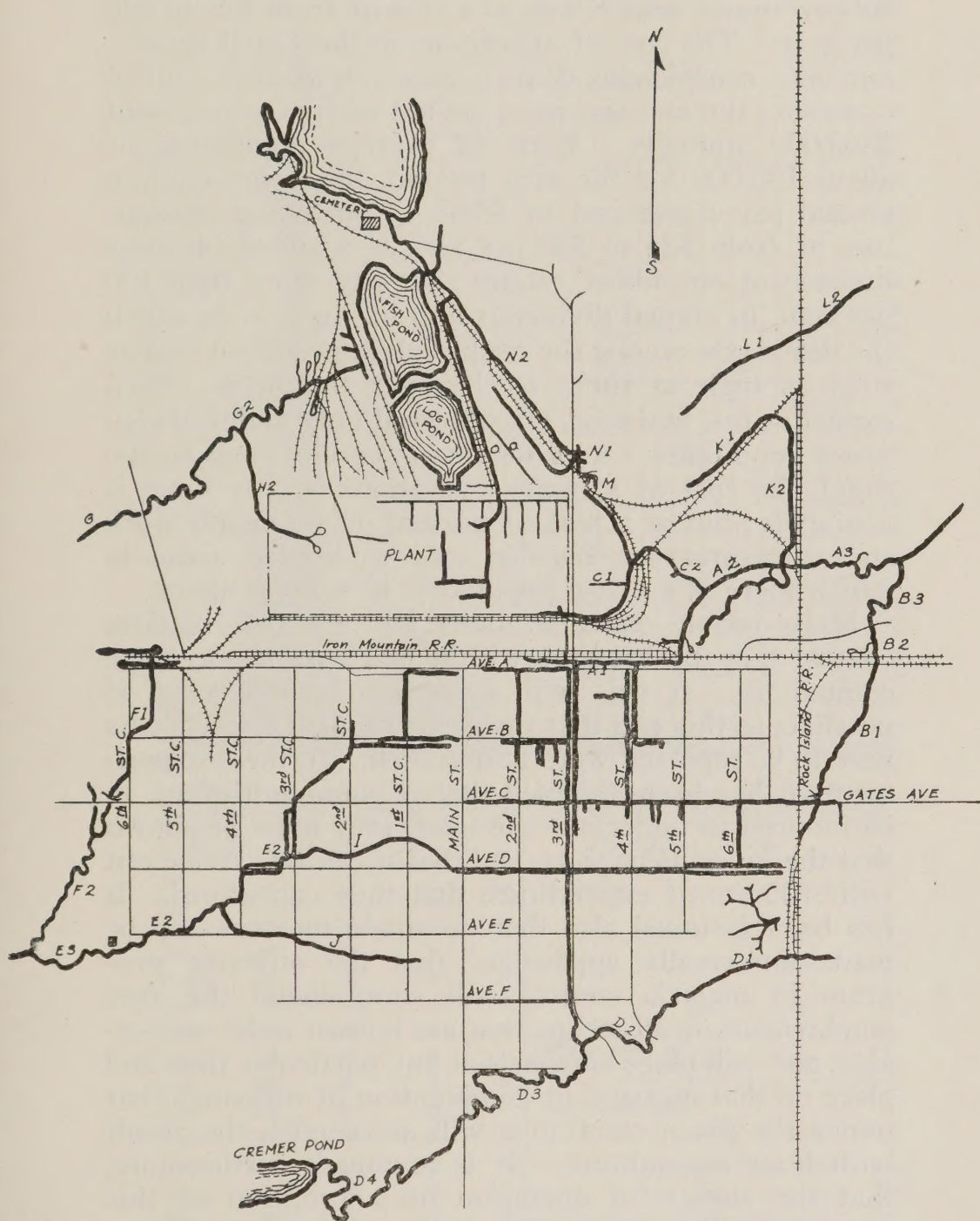


Fig. 1.—Map of Crossett, Ark., showing location of streams and ponds.

to 1905, were accomplished at a cost of \$50 per acre treated at Klang and \$250 per acre at Port Swettenham. More recently, large areas have been treated on rubber estates near Klang at a cost of from \$25 to \$30 per acre. The cost of operations in the Canal Zone—our most conspicuous demonstration in malaria control—was on the average for a period of five years about \$365,000 annually. With an average population of about 100,000 for the area treated, this represents an annual per capita cost of \$3.65. Controlling mosquitoes at from \$25 to \$30 per acre is a sound business investment on rubber estates that pay more than 100 per cent. in annual dividends and in a region in which the death rate among the coolies on unprotected estates runs as high at times as 176 per thousand. Such expenditures, however, are practical only under exceptional conditions. As a necessary part of digging the canal, the cost of sanitary operations on the Zone is negligible; but as a part of normal public health work such measures are feasible only in limited areas in which there is a dense population to support them.

More recent demonstrations indicate that malaria control may be brought within reach of the average community. It was with a view to contributing, if possible, to this end that the series of field experiments here to be reported were undertaken. In these experiments it has been assumed that if communities are to be induced to undertake the work they must be shown that the investment pays, and that it can be carried out within limits of expenditure that they can afford. It has been assumed also that no single measure can be made universally applicable; that the effective program in malaria control will comprehend the free employment of all means that are known to be serviceable, and will place emphasis at any particular time and place on that measure or combination of measures that under the given conditions will accomplish the result with least expenditure. It is assumed, furthermore, that the successful operation of a program of this character will presuppose, on the part of the person administering it, definite understanding of the conditions under which the work is to be done and of the possibilities and limitations of each of the measures that he is to employ. No attempt has been made, therefore, in these first experiments to put into operation a

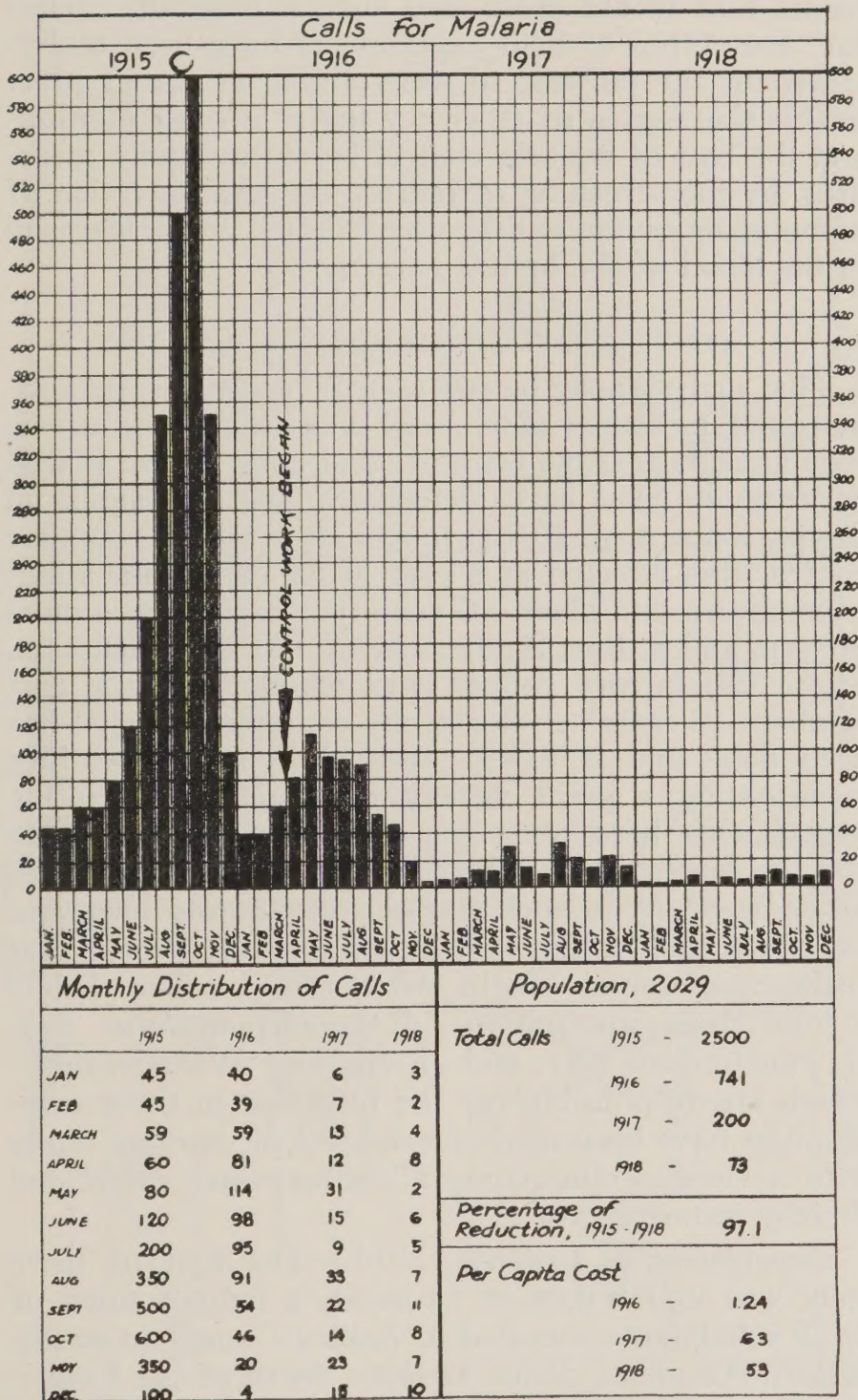


Fig. 2.—Record of malaria control by antimosquito measures, Crossett, Ark., 1916-1918.

full program of malaria control, but rather to try out the possibilities of some of the more important elements that would enter into such a program. Thus far, four types of field experiments have been undertaken for the purpose of ascertaining as far as practicable the degree of efficiency under given conditions and the cost of malaria control by antimosquito measures, by the screening of houses, by administration of immunizing quinin and by direct attack on the parasite in the blood of the human carrier.

I. CONTROL BY ANTIMOSQUITO MEASURES

That malaria may be successfully controlled by antimosquito measures alone, and that this procedure is economically feasible for cities and large towns, is well understood. The early demonstrations at Ismailia in Egypt, a town of 10,000 inhabitants, where complete control was effected at a cost of \$1 per capita initial expenditure and about 40 cents per capita for annual upkeep, and at Port Said, a city of 100,000 population, where satisfactory control was maintained at a cost of about 10 cents per capita, are examples of what has been done and is being repeated in many localities representing a great variety of conditions. In the experiments here reported, effort has been made to test the feasibility of malaria control in small communities by resort to such simple antimosquito measures as would fall within the limits of expenditure that such communities might well afford. The habits of the three mosquitoes—*A. quadrimaculatus* Say, *A. punctipennis* Say, and *A. cruzians* Wiedermann—which are responsible for the infection in these communities have been made the subject of constant study with a view to eliminating all unnecessary effort and thereby reducing cost.

Experiment at Crossett, 1916.—The first of these tests was undertaken at Crossett, a lumber town of 2,129 inhabitants, situated in Ashley County in southeastern Arkansas, about 12 miles north of the Louisiana line. Crossett lies at the edge of the so-called "uplands," in a level, low-lying region (elevation 165 feet), with sufficient undulation to provide reasonably good natural drainage. Climatic conditions and abundant breeding places favor the propagation of

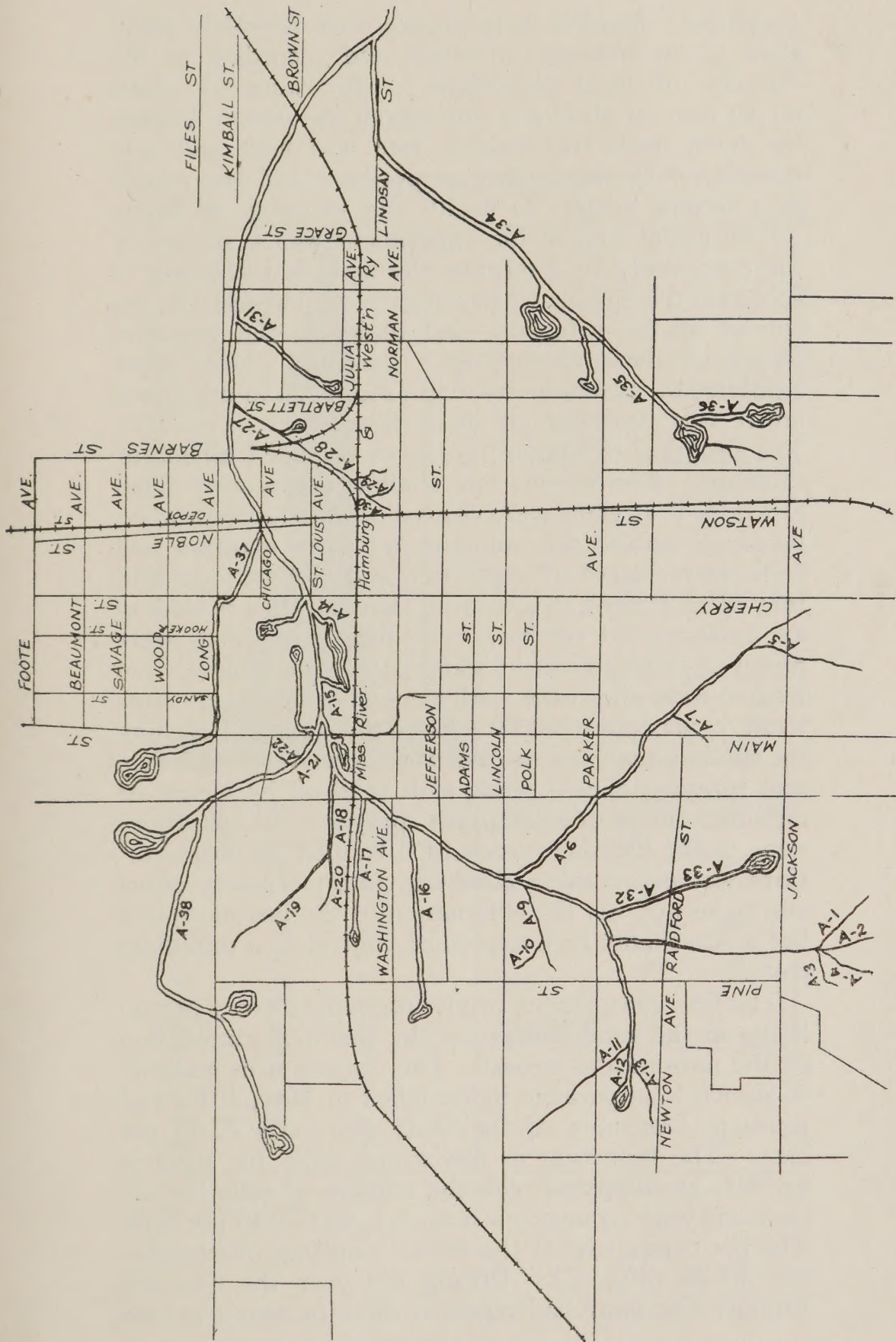


Fig. 3.—Map of Hamburg, Ark. showing location of streams and ponds.

anopheles. Malaria in its severe form is widely prevalent as an endemic infection, and according to the estimate of local physicians is the cause of about 60 per cent. of all illness throughout the region. Within the town itself the malaria rate was high and was recognized by the lumber corporation and the people as a serious menace to health and working efficiency.

The initial step in the experiment was a survey of the community to determine the malaria incidence, to ascertain the species of mosquitoes responsible for the spread of the infection, and to locate the breeding places of these mosquitoes. Breeding places were exhibited on a community map (Fig. 1), and organized effort was centered on their destruction or control. The program of simple measures excluded all major drainage. Borrow pits and shallow ponds were filled or drained; streams were cleared of undergrowth when necessary to let the sunlight in; their margins and beds were cleared of vegetation and obstructions; and they were trained to a narrow channel, thus providing an unobstructed off-flow. Artificial containers were removed from premises; water barrels on bridges were treated with niter cake. All remaining breeding places were regularly treated by removing vegetation, opening up shallow margins to give free access to small fish, and spraying once a week with road oil by means of automatic drips or a knapsack sprayer. All operations were under the supervision of a trained lay inspector. Care was exercised to eliminate all unnecessary effort and to secure, not the elimination of the last mosquito, but a reasonably high degree of control at a minimum cost.

The first conspicuous result apparent to every person living in the community was the practical elimination of the mosquito as a pest. The reduction in malaria, as shown by a parasite index taken in May, 1916, and again in December of the same year, was 72.33 per cent. The reduction in physicians' calls for malaria in 1916, as compared with the number of calls for the previous year (company's records), was 70.36 per cent. The per capita cost of the work—omitting overhead—was \$1.24 (Fig. 2). During the year the Crossett Lumber Company had repeated these measures at two

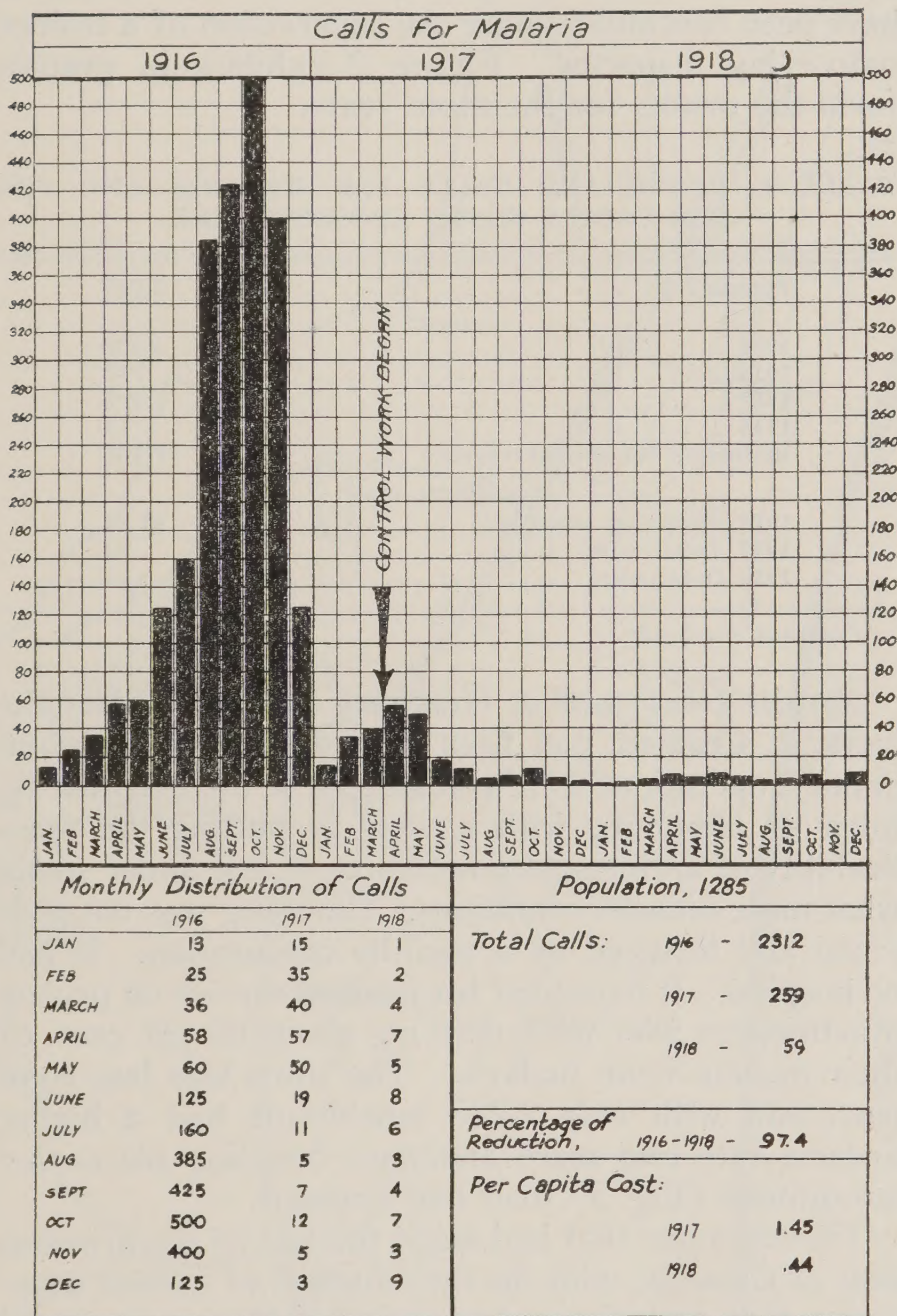


Fig. 4.—Record of malaria control by antimosquito measures, Hamburg, Ark., 1917-1918.

of its large logging camps with results that were convincing as to the soundness of the investment.

At the end of 1916 the community took over the work, and for two years has maintained it at its own expense and under its own direction. The measures have been continued under the supervision of a trained native lay inspector. Figure 2 exhibits in graphic form the results for the three years.

TABLE 1.—PHYSICIANS' CALLS FOR MALARIA AND THE PER CAPITA COSTS, CROSSETT, ARK.

Population	2,029
CALLS*	
1915	2,500
1916	741
1917	200
1918	73
Reduction for the three years	97.1%
PER CAPITA COST	
1916 (omitting overhead)	\$1.24
1917 (total cost)	.63
1918 (total cost)	.53

*Company's records.

Results Confirmed at Hamburg (1917).—After the work at Crossett had been turned over to the community, operations were transferred to the neighboring town of Hamburg with a view to putting the practicability of antimosquito measures to test under somewhat more difficult conditions. Hamburg was not governed and financed by a wealthy corporation. It had no hospital. It depended for medical service on private practitioners who were deriving about 60 per cent. of their income from malaria. The town was less compact, and with only 1,285 inhabitants had a higher malaria rate and more abundant breeding places for mosquitoes (Fig. 3) than had Crossett.

The measures that had stood the test of the previous year at Crossett, with the introduction of certain economies that experience had suggested, were repeated here. Physicians' calls were reduced from 2,312 in 1916 to 259 in 1917, a reduction of 88.8 per cent. For the latter half of the year—July to December, inclusive—there were only forty-three calls for malaria in 1917, as compared with 1,995 calls for the same period

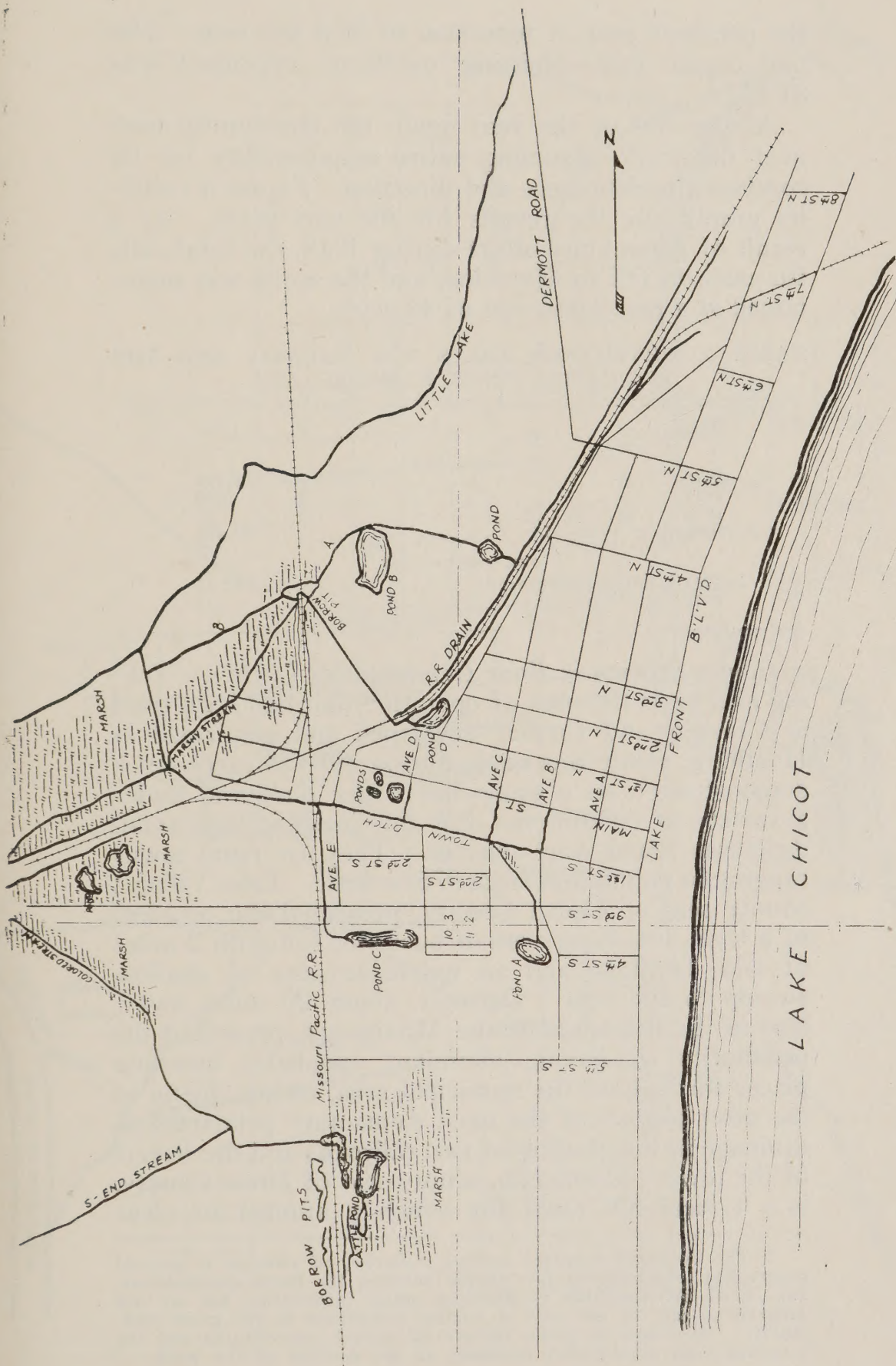


Fig. 5.—Map of Lake Village, Ark., showing Lake Chicot and main natural drainage system

the previous year, a reduction of 97.8 per cent. The per capita cost—omitting overhead expenses—was \$1.45.¹

At the end of the year again the community took over the work, assuming entire responsibility for its continued maintenance and direction. Figure 4 exhibits graphically the results for the two years. As a result of community effort during 1918, the total calls for malaria fell to fifty-nine, and the work was maintained at a per capita cost of 44 cents.

TABLE 2.—PHYSICIANS' CALLS FOR MALARIA AND THE PER CAPITA COSTS, HAMBURG, ARK.

Population	1,285
CALLS	
1916	2,312
1917	259
1918	59
Reduction 1916-1918	97.4%
PER CAPITA COST	
1917 (omitting overhead)	\$1.45
1918 (total upkeep)	.44

Demonstration in Four Communities (1918).—Taking as a basis the plan of operation that had been tried at Crossett and further developed and confirmed at Hamburg, effort was made during 1918 to carry out a demonstration on a somewhat larger scale and under a variety of conditions. For this purpose four small Arkansas towns were selected. They are rural towns ranging in population from 975 to 3,023. Lake Village, county seat of Chicot County, presented the problem of a level, low-lying area of buckshot soil with 2 miles of lake frontage and an extensive area of shallow swamp in the rear. Dermott, about 20 miles away, also in the flat lands of the Mississippi, presented the peculiarity of having abundant anopheles breeding places throughout the municipal area, owing chiefly to the utter neglect of the most elementary principles of drainage in the grading of two railroads and the streets of the town. Monticello, county seat of Drew County, is a typical hill town for which a number of clear

1. The overhead expenses omitted comprise, in addition to general supervision, expenditures for outside surveys, for blood examinations, etc., which are desirable as affording useful information but are not properly a part of the cost of control operations in the given community. The costs as given include all capital expenditures and the complete local organization necessary to the conduct of the work.



Fig. 6.—Map of Dermott, Ark., showing location of mosquito breeding places to be treated.

streams with adequate fall over a stiff clay soil furnished an abundant supply of anopheles. Bauxite, a rambling mining community of about 2,500 inhabitants, presented the difficulties of a large area to be treated, a heavy sand flow in the beds of its numerous small streams, and extensive hillside seepage areas offering ideal breeding conditions. Figures 5, 6, 7 and 8 exhibit for these communities the breeding places to be treated.

A preliminary survey of each community at different seasons during the previous year made it possible to omit from the working plans much that otherwise would have been waste effort. Each community was presented in advance with an estimate of its malaria prevalence, a chart exhibiting its breeding places, a working plan with budget, and an estimate of what might be expected as a result in degree of malaria con-

TABLE 3.—PHYSICIANS' CALLS FOR MALARIA AND THE PER CAPITA COSTS, LAKE VILLAGE, DERMOTT, MONTICELLO, AND BAUXITE, ARK.

	Lake Village	Dermott	Monticello	Bauxite
Population	975	2,760	3,023	2,500
Physicians' calls for malaria:				
1916	1,817	1,399	1,413	862
1917	1,388	1,248	1,274	729
1918	83	162	137	172
Per cent, reduction, 1917-18	94.8	87.8	89.8	78.4
Per capita cost, 1918	\$1.25	\$0.54	\$0.46	\$1.11

trol. The community in each case provided the funds required except for general supervision, and agreed to assume entire responsibility for the work after the first year.

The plan of operation followed at Crossett and Hamburg, with improvements suggested by experience and adaptations to local conditions, was repeated in each of these towns. For the four communities combined, physicians' calls for malaria were reduced from 5,065 (the average for the two previous years) to 554, a reduction of 89.1 per cent. The per capita cost of the entire work, omitting general overhead expenses, was 74 cents. Results and costs by communities are graphically exhibited in Figures 9, 10, 11 and 12.

Comparison of cost of operations with results accomplished in these six towns tends to show that malaria control in such communities, considered merely as a

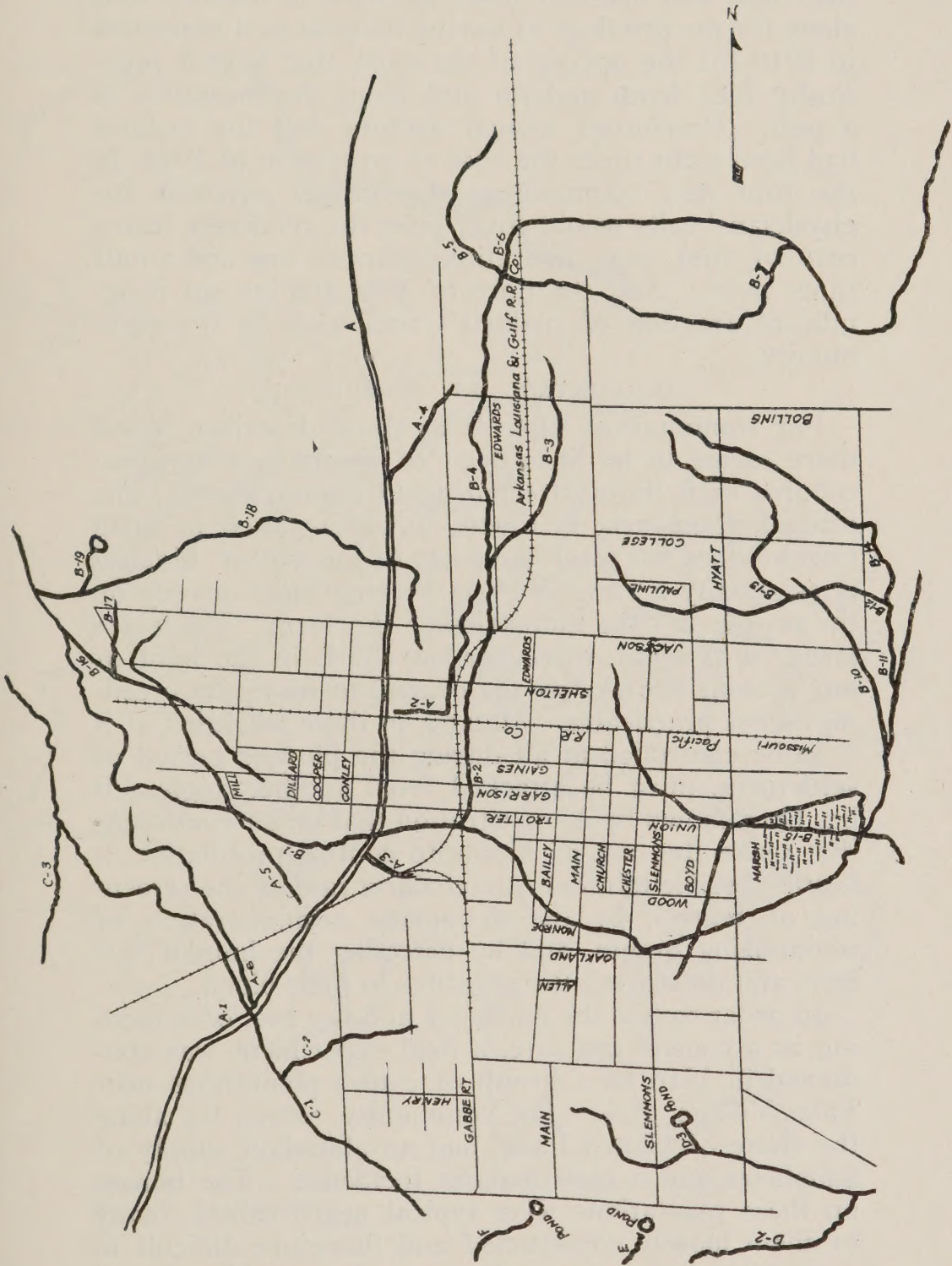


Fig. 7.—Map of Monticello, Ark., showing location of mosquito breeding places to be treated.

business proposition, pays. At two dollars per physician's call, Crossett has been paying annually more than four and one-half times as much in doctors' bills alone for the privilege of having malaria as it expended in 1918 for the upkeep of the work that kept it practically free from malaria and from the mosquito as a pest. Hamburg's annual doctors' bill for malaria had been eight times the cost of protection in 1918. In the four new communities the annual payment for physicians' calls would cover even the relatively heavy cost of first year operations almost one-and-a-half times over. And the doctors' bills are but an insignificant fraction of malaria's total cost to the community.

II. CONTROL BY SCREENING

For communities situated as those described above there seems to be little need of resort to other procedures than those directed against mosquitoes. The control of malaria in towns, however—even in small towns—does not reach the heart of the matter. Malaria is essentially a rural disease, bearing most heavily on the people and the industries of the farm. There are large rural areas, moreover, in which in the light of our present knowledge, the control of mosquito breeding is not practicable. Malaria in these localities, if it is to be controlled at all during the pioneer period of settlement, must be attacked from another angle. It has been shown by demonstration that under conditions that make the cost of mosquito control prohibitive, it is still possible to reduce the malaria rate by the screening of houses, by the systematic administration of immunizing quinin, and by detecting the human carriers and destroying the parasites in their blood.

In order to test the efficiency and the cost of screening as a control measure, a field experiment was conducted in 1916 on a group of cotton plantations near Lake Village, Ark. The community, which lay along the shore of Chicot Lake, had an abundant supply of anopheles and a high malaria incidence. The houses on these plantations were typical negro cabins, many of them loosely constructed and therefore difficult to protect against entrance by mosquitoes. All selected houses were screened with galvanized wire cloth, 16 mesh, the work being carefully done by carpenters and without cost to the tenants. The people were taught

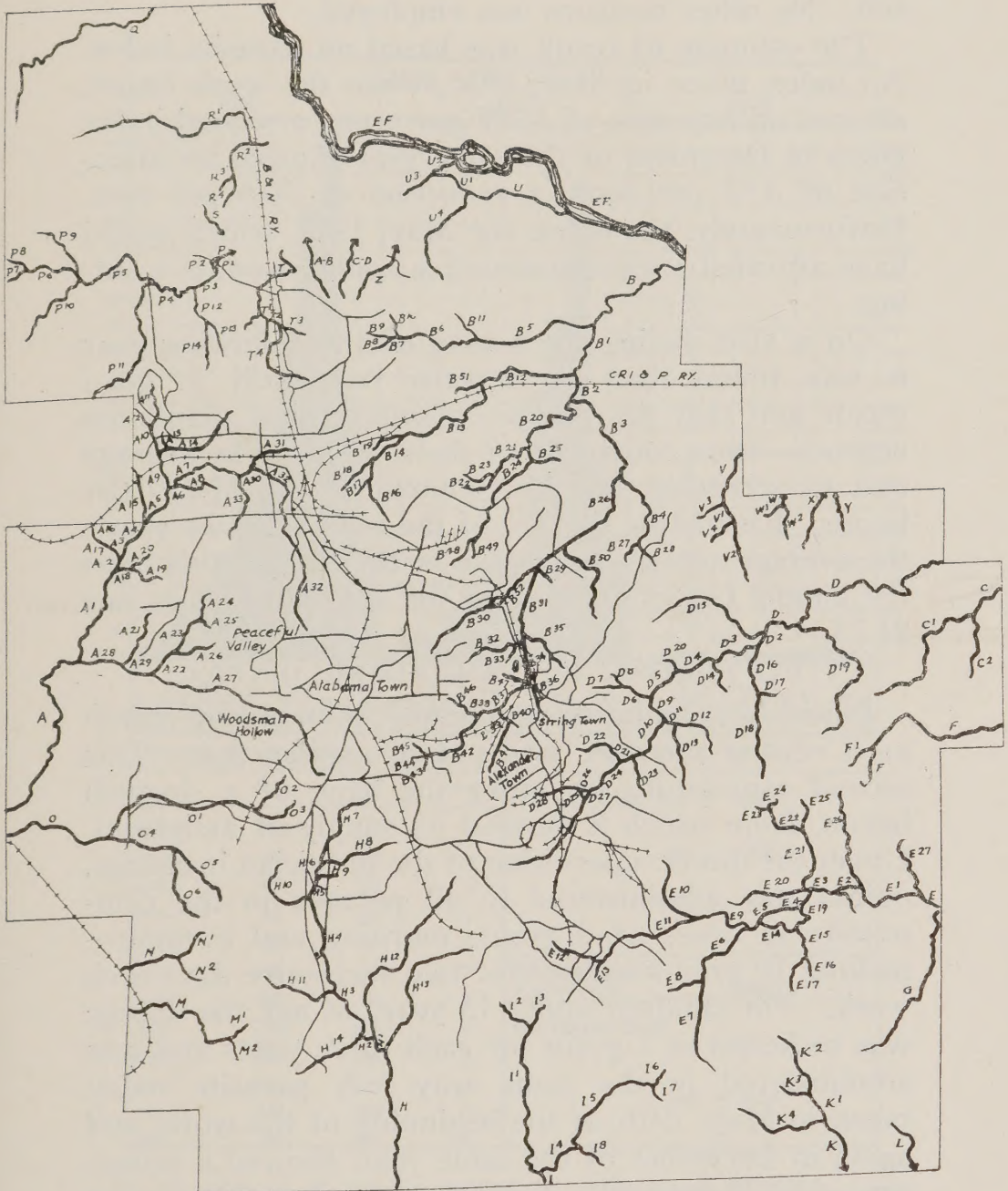


Fig. 8.—Map of Bauxite, Ark., showing location of mosquito breeding places to be treated.

by house-to-house visits the importance of keeping the screens in good condition and the dangers of exposure to mosquitoes on the outside after dark. Each home was inspected at regular intervals throughout the season. No other measure was employed.

The estimate of result was based on parasite index. An index taken in May, 1916, when the work began, showed an infection of 11.97 per cent.; a second index taken in December of the same year showed an infection of 3.52 per cent., a reduction of 70.6 per cent. Unfortunately, the index for May, 1917, which would have afforded a more instructive comparison, is wanting.

On a visit during the season of the following year it was found that the screens were still in good repair and that the people—mainly typical plantation negroes—were convinced of their value. The average cost of screening for the community was \$14.59 per house. Estimating the life of the screen at two years, the average annual cost would be \$7.29. On this basis the annual per capita cost of the screening alone was \$1.75.

III. CONTROL BY IMMUNIZING QUININ

In another plantation community, immunizing quinin as a control measure was put to similar test. This second community lay along the bank of a sluggish bayou, from which it derived its supply of anopheles. Under the direct supervision of the physician in charge, quinin was administered to all persons in the community in doses of 5 grains morning and evening—making 10 grains a day—for two successive days each week. For children under 15 years of age the dosage was reckoned at 1 grain for each three years and was administered in the same way. A parasite index taken in May, 1916, at the beginning of the work, and again in December of the same year, showed a reduction of 64.45 per cent. Again the omission of the index for May, 1917, must be regretted. The per capita cost of the work, omitting the overhead expense, was 57 cents.

These tests in malaria control by screening and by the administration of immunizing quinin are to be regarded as preliminary and their results as suggestive

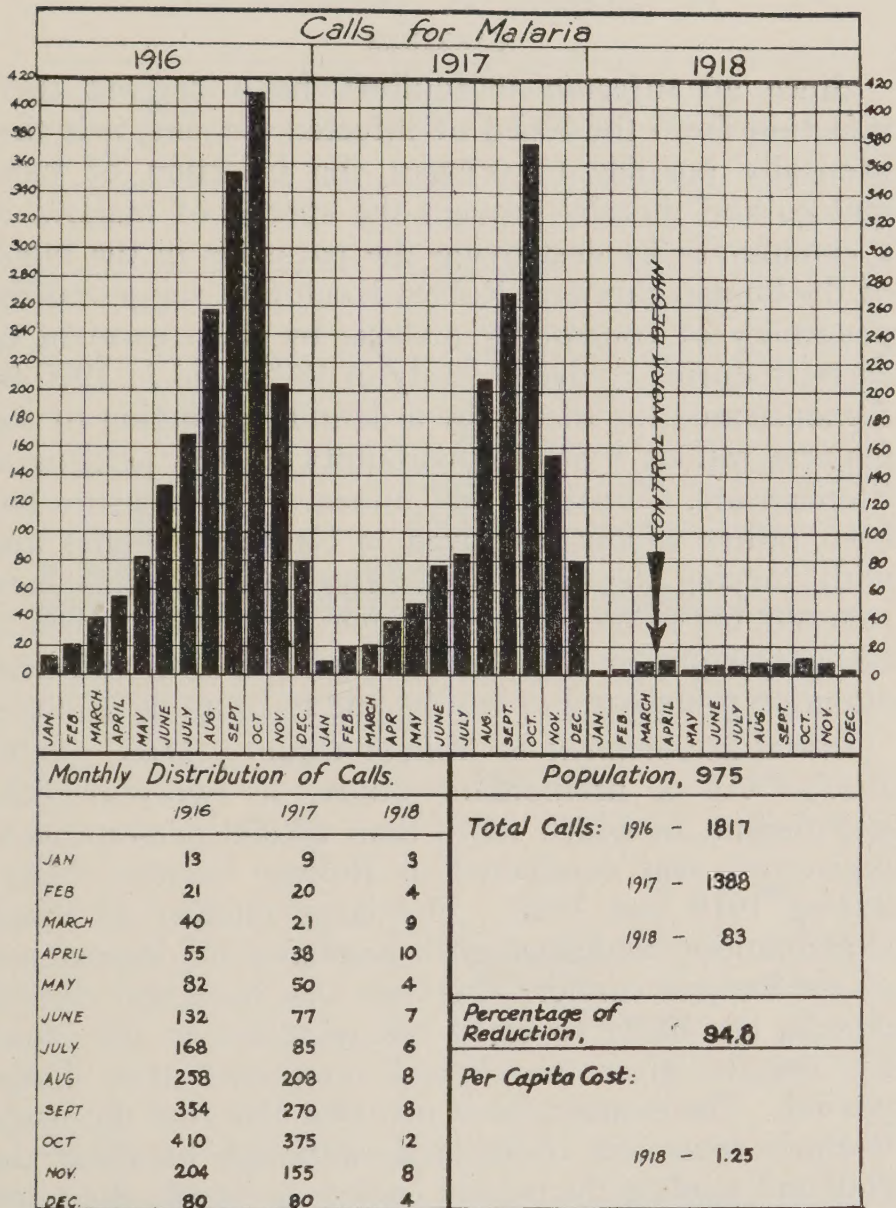


Fig. 9.—Record of malaria control by antimosquito measures, Lake Village, Ark., 1918.

only. Generalization may be attempted only when they have been carried out on a much larger scale under a variety of conditions and with a more reliable measure of results.

IV. CONTROL BY TREATING THE CARRIERS

Since all infected mosquitoes have derived their infection from the blood of infected persons, it is theoretically possible to prevent the infection of mosquitoes and thereby prevent the spread of malaria in a community by destroying the parasites in the blood of the human carrier. Robert Koch first suggested the possibility of controlling malaria by the treatment of carriers during a visit to Italy in 1898, and in 1900 he demonstrated his theory by a definite reduction of the malaria rate in a small community of 734 persons at Stephansort, German New Guinea. The measure has been rather widely employed in German colonies and with varying degrees of success. Malaria has been reduced, but in no community does the method seem to have been put to an adequate test and with sufficient attention to measure of results and to counting of costs.

Initial Experiment in Bolivar County, Miss. (1916-1917).—As a preliminary study, a two-year field experiment, in which more than 30,000 persons were registered, was conducted in Bolivar County, Miss., during 1916 and 1917. The large number of blood examinations confirmed with emphasis the importance of the malaria carrier. Persons who have had clinical attacks are likely to carry the parasites in the blood for months after the clinical symptoms have disappeared. The examinations revealed also that the usual doctor's treatment of malaria, although breaking the chill and sending the patient back to his work, does not, in most cases, sterilize his blood. The results of chill tonics, on which so many people depend, are still less satisfactory. A very large percentage of malaria patients treated by physicians, or by the use of chill tonics, continue for months, after apparent cure, to carry the parasites and to be therefore subject to relapse and a possible source of infection to others. These tests, furthermore, established the fact that 10

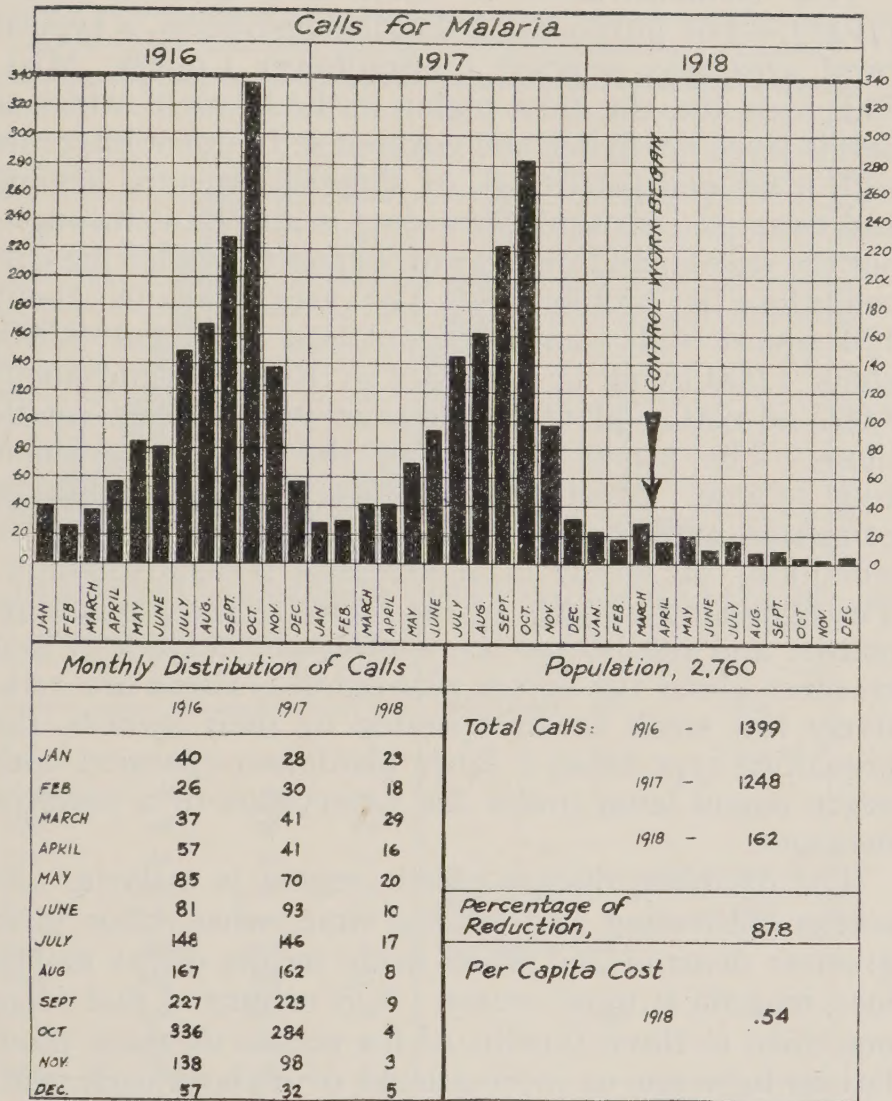


Fig. 10.—Record of malaria control by antimosquito measures, Dermott, Ark., 1918.

grains of quinin a day for eight weeks sterilized the blood of about 90 per cent. of the carriers to whom it was administered.²

With this standard course of treatment established, effort was made during 1918 to carry out a test demonstration in malaria control by treating the carriers.

Test Demonstration in Sunflower County, Miss. (1918).—For purposes of the demonstration, a typical rural area was selected in Sunflower County, Miss. This area, like the delta region in the heart of which it lies, is level, low-lying, and covered at frequent intervals with a net-and-patchwork of sluggish streams, bayous and swamps. Mosquito breeding is abundant throughout the season, and the cost of its control under present conditions is prohibitive. The area contains about 100 square miles and a population of about 9,000, about 1,000 living in the town of Ruleville and about 8,000 on cotton plantations under typical delta conditions. The blacks outnumber the whites by about four to one. Most of the negroes can read, but as compared with a white population living under similar conditions the grade of intelligence is relatively low. The dominant industry of the region is the growing of cotton, and the life of the community centers in and revolves about the cotton plantation. There are relatively few small farms operated by their owners, the prevailing type being a large plantation operated with negro tenant labor under the supervision of a resident manager.

The disabling disease of the region is malaria. At cotton cultivating and picking time, when labor is in greatest demand and when delay means direct money loss, malaria is most severe. It is estimated that from one third to three fourths of the people on these plantations have one or more attacks of malaria each year, and that 70 per cent. or more of all sickness disability in the community is due to this cause. On one plantation, for example, having a tenant population of about 600, the average annual doctor's bill for the last ten years has been approximately \$4,000. Of this sum about \$3,000, or \$5 per capita, is attributed by the manager to malaria. The loss to the tenant and the land-

2. There is reason to believe that this result does not hold for all conditions. It seems to be much more difficult, for example, to sterilize the blood of carriers in certain tropical regions.

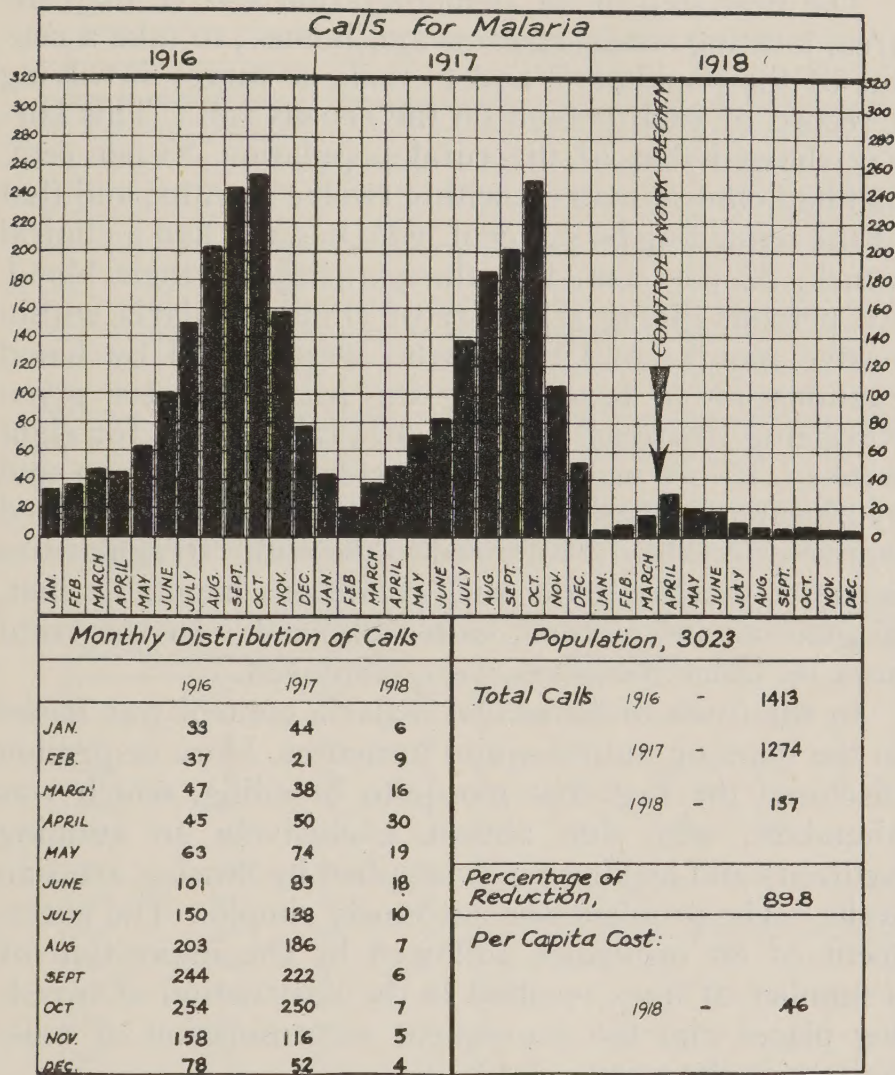


Fig. 11.—Record of malaria control by antimosquito measures, Monticello, Ark., 1918.

lord in crop returns is much larger. And since the landlord must look to the tenant's crop both for return on his capital investment in land and equipment and for reimbursement for his large current advances to his tenant families, he is most deeply concerned in any condition that impairs the health and efficiency of the workers on his plantation.

The first step in the demonstration was to map the area, locating roads, streams and homes; to take a census of the population, and to make a survey involving a record of each person on the census roll. This survey showed that of the rural population 40 per cent. had had clinical malaria within twelve months, and that of the remaining 60 per cent. who had not had a clinical attack, 22 per cent. had the parasites in their blood. All persons giving a history of clinical malaria within twelve months and those who were found by blood examination to be carrying the parasites were given sterilizing treatment, namely, 10 grains a day for eight weeks. Effort was made by personal instruction and by repeated house-to-house visits to have the prescribed course of treatment followed to the end. Irregularities occurred and are under such conditions inevitable; but, in general, instructions were followed. In the rural area no other measures were employed.

In the town of Ruleville, malaria control was based in the main on antimosquito measures. Here inspection disclosed the fact that mosquito breeding, which was abundant, was due almost exclusively to running hydrants and leaking pipes supplied by flowing artesian wells. The problem was extremely simple. The enactment of an ordinance followed by the imposition of a number of fines resulted in the destruction of breeding places and the consequent extermination of mosquitoes in the town.

Results.—Unfortunately no reliable record of the number of physicians' calls within the area before the work began is available, and the second parasite index will not be taken until next season. The results of the test, so far as they may be estimated in advance of the final report, may be thus summarized:

1. There has been no transmission of malaria within the town of Ruleville during the year, and the town has been free from the mosquito as a pest.

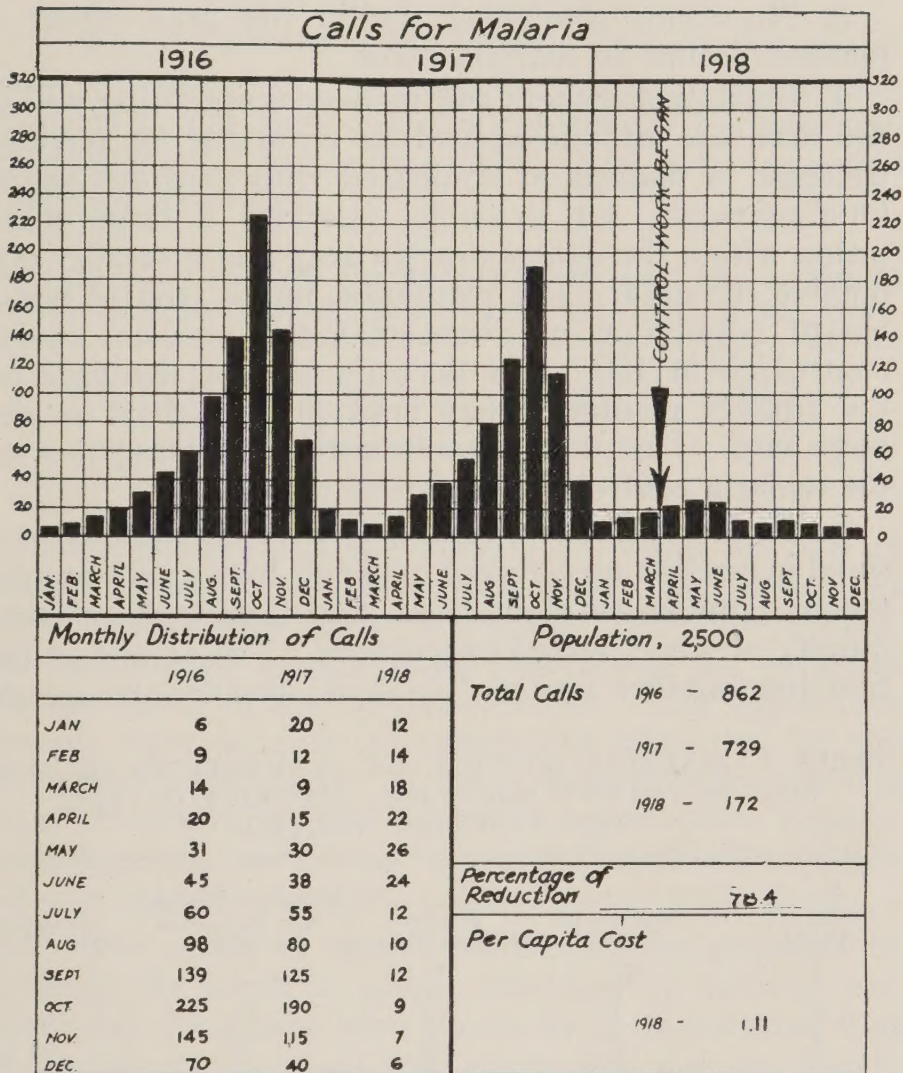


Fig. 12.—Record of malaria control by antimosquito measures, Bauxite, Ark., 1918.

2. The degree of malaria control resulting from the measures carried out in the rural area is estimated by the director in charge at approximately 80 per cent. This estimate is based on the record of malaria histories, intimate observation during the season, informal reports by tenants and plantation managers, and regular monthly reports submitted by physicians.

3. Physicians practicing within the area report a marked decline in malaria cases.

4. Plantation owners and managers operating within the area are of one accord in reporting an obvious decrease in malaria as compared with previous years. One manager, for example, operates a large plantation within the demonstration area and a smaller one outside the area. The plantation under control has a tenant population of about 600, the one not under control about 180. The doctor's bill for the year on the smaller plantation has been greater than on the large one. This difference he attributes altogether to the malaria control on the larger plantation.

5. These reports and estimates were checked by personal inspection on a recent house-to-house visit among tenant families on plantations, and families in a community of small landed proprietors. The record of the first ten families visited (Table 4) typifies the result.

TABLE 4.—MALARIA CONTROL ON PLANTATIONS OF SUN-
FLOWER COUNTY, MISS., 1918: RECORD FOR FIRST
TEN FAMILIES VISITED

Order of Visit	Number in Family	Positive Malaria History	Negative History but Parasites in Blood	Malaria This Year
1	12	10	..	3
2	6	4	..	0
3	4	0	1	0
4	2	0	0	0
5	8	0	2	0
6	7	1	5	0
7	4	3	..	0
8	9	9	..	0
9	1	1	..	1
10	5	4	..	0
Total	58	32	8	4

Percentage of Reduction 87.5

Neighboring counties in Mississippi have asked that the work be extended to them and have indicated a willingness to provide the funds. The demonstration,

however, is only begun. It is suggestive, but far from complete. No conclusion will be attempted until the test has been continued over a period of years within the same area, has been tried under a variety of conditions, and has been submitted to a more definite measure of results.

SUMMARY AND CONCLUSIONS

1. For the average town in our Southern states having a thousand or more inhabitants and a reasonably high infection rate, malaria control by antimosquito measures is economically feasible; it is, in fact, a sound business investment.

TABLE 5.—SUMMARY OF RESULTS OF MALARIA CONTROL DEMONSTRATION IN SUNFLOWER COUNTY, MISS., 1918

Population rural area	8,000
Estimated degree of control	80%
Per capita cost	\$1.08
Per capita cost for Ruleville	\$.41

2. In heavily infected regions, in which the cost of mosquito control would be prohibitive, the amount of malaria may be greatly reduced by resort to screening, to immunizing quinin, or to destroying the parasites in the blood of the human carriers. The indications would seem, in fact, to justify the hope that by the systematic application of these measures the malaria in a community may be held within reasonable bounds, and that this result may be accomplished within limits of cost that the average community may well afford.

3. The people in these communities are prepared to provide the funds by public taxation for malaria control when they have been shown by demonstration that the program proposed will accomplish definite results that justify the expenditure.

4. The results thus far accomplished would seem to justify continuing these field experiments until the principal procedures that have been found useful in controlling malaria have been pretty thoroughly tested separately and thus evaluated. It will then be possible to operate intelligently a combination program in which each control measure will be given its place and will receive varying emphasis from time to time according

to the local conditions that have to be met. This freedom in the use of our tools will in turn contribute toward the object that we have in view, namely, the highest degree of malaria control consistent with a reasonably low per capita cost.



